

security particles, one skilled in the art will recognize that the teachings regarding security particles are illustrative and exemplary, and are not limiting of this invention.

[0066] The security particles referred to herein are generally characterized by, among other things: having a general lack of body color, or an “invisible” appearance under visible light; precise and uniform size at mean diameters ranging from about 50 to about 200 microns; application techniques that provide for uniform loading and control over large areas (in one embodiment, as high as 3,000 particles per square decimeter); a significant range of colors that extend beyond more commonly available UV colors such as blue. For example, the additional security pigment colors include red and yellow. These security particles are generally contrasting with a background, thus many aspects of a distribution of security particles may be used for security purposes.

[0067] As used herein, “no body color” generally means that each security feature is substantially white, but can fluoresce with other colors—and that the security particle is capable of substantially blending with other colors, such as the colors in a surrounding substrate. A security particle having a “body color” is characterized as a security particle that has, at least in part, a color under white light illumination.

[0068] One embodiment of security particles includes security particles that are formed of materials such as plastic powders containing a small percentage of any one of several fluorescent pigments. The security particles may be manufactured in several fluorescent colors and in several particle size ranges above 50 microns up to about 200 microns. Related structures may be formed and based on identical or similar materials. One example of related structures is powdered particles that may include a variety of coatings and/or ink formulations. These related structures are generally characterized by having particle size ranges below 50 microns. These smaller structures may be used for other purposes, such as, in a non-limiting example, to modify the general appearance (e.g., color) of a background to the security particles. One presently preferred security particle that meets these various criteria is known as PolyStar™, and is available from Spectra Systems of Providence R.I. **FIG. 35** depicts a normalized spectral response for the PolyStar™ security particles. In **FIG. 35**, the security particles exhibit peaks with half-widths of about 70 nm. The red security particles have a noticeably more narrow peak than the yellow, green or blue.

[0069] Security particles are particularly well suited for coding products which would naturally attract and/or retain at least some of the particles. Non-limiting examples of retentive materials include textiles and porous materials. By applying various particle combinations on the product, or on a substrate attached to the product, a code can be created and associated with the product. Although electrostatic attraction may cause these particles to be adequately retained, enhanced binding can be achieved using appropriate materials, for example, a mesh incorporated into the product or binding agents such as starches or hair spray types of products.

[0070] In other embodiments, the security particles are included within the material used to form the substrate. For example, in one embodiment, the security particles are

disbursed within a matrix, such as pulp, for the generation of security paper. However, it should be noted that the foregoing embodiments are not limiting of techniques for the formation of security particles, or security features, as referred to herein.

[0071] Additional coding combinations can be made by incorporating fluorescence emission or body color into the security particle. With UV excitation, for example, at least five unique wavelength categories or frequency ranges can be created. Combining these five different wavelength categories, $((2^F)-1)$ combinations are possible. In this function, F represents the number of wavelengths from which to choose. That is, with five wavelengths, $(2^5-1)=31$ combinations may be realized. Where other characteristics are included, a greater number of combinations are possible. For example, including one other characteristic provides for $((2^F)^D-1)$ combinations, where D additionally represents the number of options in the second characteristic. That is, with five wavelengths and three diameters, $((2^5)^3-1)=32,767$ combinations are possible.

[0072] In addition, the loading factors of various security particles can be employed as a further variable. For example, there may be a set of security particles having two members, the first comprised of red particles of 50 micron diameter and the second comprised of red (or green, or blue, or yellow) particles having an 80 micron diameter. The first particles may be present with a loading factor of 20 per square centimeter, while the second particles may be present with a loading factor of 40 particles per square centimeter. By counting the numbers of particles per unit area of each type, one may determine the information encoded by the selected security particles. For example, a paper document having this particular set of security particles is identified as a first type of negotiable instrument, while another paper document having a different set of security particles (e.g., red particles of 25 micron diameter and 80 micron diameter with loading factors of 50 per square centimeter and 100 per square centimeter, respectively) is identified as a second type of negotiable security. Furthermore, one may verify the authenticity of the negotiable security by verifying that the expected set of security particles are actually present with the expected size ranges and loading factors.

[0073] Further examples of coding techniques are disclosed in the International Application PCT/US00/42065, filed under the PCT and published as International Publication Number WO 01/37207 A1; and the corresponding U.S. patent application Ser. No. 09/708,273 entitled “Authentication and Coding by Size, Shape and Fluorescence,” filed Nov. 8, 2000, Lawandy. The disclosures of these applications are incorporated by reference herein in their entirety.

[0074] Detection of the security particles is performed using an appropriately configured device, such as the non-limiting example of the VERICAM™ produced by Spectra Systems Corporation of Providence R.I. Aspects of detection equipment, and operation thereof, are now described.

[0075] Hand-Held Authentication Device

[0076] Referring to **FIG. 1** and **FIG. 2**, the hand-held apparatus for security feature authentication, or device **5**, includes a CPU **10**, such as an embedded microprocessor, an internal read/write memory **15** and optional, preferably non-volatile, mass storage **18**. Also included is a digital